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CALIBRATION PROCEDURE

NI 5102

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Introduction

This document contains step-by-step instructions for writing a calibration utility for the NI 5102 digitizer. This calibration procedure is intended for metrology labs.

NATIONAL INSTRUMENTS™

External Calibration

External calibration requires using a high-precision oscilloscope calibrator to verify and adjust calibration constants. This process replaces all calibration constants in the EEPROM and is equivalent to a factory calibration. Because the external calibration procedure changes all EEPROM constants, it invalidates the original National Institute of Standards and Technology (NIST) traceability certificate. If an external calibration is done with a NIST-certified voltage source, a new NIST traceability certificate can be issued.

Note The external calibration interval for the NI 5102 is one year. You can shorten this interval based on the demands of your application.

Self-Calibration

Self-calibration, or internal calibration, uses a software command and requires no external connections. Self-calibration adjusts a device for use in an environment where external variables, such as temperature, may differ from those in the environment in which the device was externally calibrated.

Equipment and Other Test Requirements

Test Equipment

Table 1 lists the equipment required for calibrating the NI 5102. If you do not have the recommended instruments, use these specifications to select a substitute calibration standard.

Table 1. Required Equipment for NI 5102 Calibration

Required Equipment	Recommended Equipment	Parameter Measured	Necessary Specifications
Signal Generator/ Ohmmeter	Fluke 9500B Oscilloscope Calibrator	Vertical Gain	DC ±40 mV to ±4.5 V, ±0.1% into 1 MΩ
		AC Coupling	Sine wave 9–13 Hz ±100 ppm, 1.8 V_{pk-pk} ±2% into 1 MΩ
		Bandwidth	1.5% amplitude flatness for leveled sine wave 100 kHz–20 MHz ±50 ppm, 1.5 V_{pk-pk} ± 2% into 1 MΩ
		Input Impedance	2-wire resistance accuracy of 0.25% for 1 MΩ measurement

Table 1. Required Equipment for NI 5102 Calibration (Continued)

Required Equipment	Recommended Equipment	Parameter Measured	Necessary Specifications
BNC Cable	—	—	50 Ω
BNC Shorting Cap	—	Vertical Offset	0 VDC ±0.1 mV
BNC T Connector	—	—	—

Test Conditions

Follow these guidelines to optimize the connections and the environment during calibration:

- Keep connections to the NI 5102 short. Long cables and wires act as antennae, picking up extra noise that can affect measurements.
- Use a 50 Ω BNC coaxial cable for all connections to the digitizer.
- Keep relative humidity between 10 and 90% non-condensing, or consult the digitizer hardware documentation for the optimum relative humidity.
- Maintain the temperature between 5 and 40 °C, or consult the digitizer hardware documentation for the optimum temperature range.
- Allow a warm-up time of at least 15 minutes after the NI-SCOPE driver is loaded. Unless manually disabled, the NI-SCOPE driver automatically loads with the operating system and enables the device. The warm-up time ensures that the measurement circuitry of the NI 5102 is at a stable operating temperature.

♦ Ensure that the PXI chassis fan speed is set to HIGH, that the fan filters are clean, and that the empty slots contain filler panels.

♦ Plug the PXI chassis and the calibrator into the same power strip to avoid ground loops.

Documentation

In addition to this calibration document, you may find it helpful to refer to the following documents:

- *NI High-Speed Digitizers Getting Started Guide*
- *NI High-Speed Digitizers Help,* which contains the following:
  - *NI-SCOPE VI Reference Help*
  - *NI-SCOPE Function Reference Help*

After you install NI-SCOPE, you can access these documents at **Start» All Programs»National Instruments»NI-SCOPE»Documentation**.

You can also download the latest versions of documentation at `ni.com/manuals`.

Software

Calibration requires the latest version of the NI-SCOPE driver on the calibration system. You can download the latest version of NI-SCOPE from `ni.com/downloads`. For installation instructions, refer to the *NI High-Speed Digitizers Getting Started Guide*.

Writing Your Calibration Procedure

NI-SCOPE includes all functions necessary for calibrating NI digitizers. Because calibration support is included in `niScope_32.dll`, you can access it through any compiler capable of calling into a 32-bit DLL. If you use a C compiler, include the `niScopeCal.h` header file, which defines all calibration-specific functions and briefly explains the parameters. LabVIEW support is installed in `niScopeCal.llb` and all calibration functions appear in the palette.

Self-Calibration Procedure

Self-calibrate the digitizer before you begin external calibration. NI-SCOPE includes self-calibration example programs that you can access at **Start»All Programs»National Instruments»NI-SCOPE»Examples**.

Note Self-calibration of the NI 5102 adjusts only the timing for random interleaved sampling (RIS) acquisitions.

Self-Calibrating the NI 5102

Complete the following steps to self-calibrate the digitizer:

1. Call `niScope_init` (niScope Initialize VI) to obtain an instrument session handle.
2. Call `niScope_calSelfCalibrate` (niScope Cal Self Calibrate VI) with **option** set to `VI_NULL`. The new calibration constants are immediately stored in the EEPROM, so you can include this procedure in any application that uses the digitizer.
3. Call `niScope_close` (niScope Close VI) to close the session handle and deallocate system resources.

External Calibration Procedures

External calibration consists of the following three steps:

1. Verifying the performance of the digitizer
2. Adjusting calibration constants
3. Reverifying after adjustment

All procedures start by calling `niScope_init` with **resetDevice** set to `VI_TRUE` and end by calling `niScope_close`. Table 1 lists the accuracies of input stimuli for specific devices.

Verifying the Performance of the NI 5102

To determine if the NI 5102 requires adjustment, verify each vertical offset specification listed in Table 2 and each vertical gain specification listed in Table 3. If any of these tests fail, externally adjust the digitizer. If any tests fail immediately after an external adjustment, return the digitizer to NI for repair.

Verifying Vertical Offset

Complete the following steps to verify NI 5102 vertical offset specifications:

1. Short-circuit channel 0 of the digitizer with the BNC shorting cap.
2. Call `niScope_ConfigureAcquisition` with **acquisitionType** set to `NISCOPE_VAL_NORMAL`.
3. Call `niScope_ConfigureHorizontalTiming` with the following parameters:
   - **minSampleRate**: `20,000,000`
   - **minNumPts**: `30,000`
   - **refPosition**: `50.0`
   - **numRecords**: `1`
   - **enforceRealTime**: `VI_TRUE`
4. Call `niScope_ConfigureVertical` with the following parameters:
   - **channelList**: `0`
   - **range**: The range corresponding to the current iteration in Table 2
   - **offset**: `0.0`
   - **coupling**: `NISCOPE_VAL_DC`
   - **probeAttenuation**: `1.0`
   - **enabled**: `VI_TRUE`

5. Call `niScope_Read` to ensure that the hardware is programmed. Set the following parameters:
   - **channelList**: `0`
   - **timeout**: `30`
   - **numSamples**: `128`
6. Wait 250 ms for the input stage to settle.
7. Call `niScope_InitiateAcquisition`.
8. Call `niScope_FetchMeasurement` with the following parameters:
   - **channelList**: `0`
   - **scalarMeasFunction**: `NISCOPE_VAL_VOLTAGE_AVERAGE`
   - **timeout**: `0`
9. Compare the resulting average voltage to the first value in the *Success Condition* column in Table 2. If the result falls outside this range, the NI 5102 has failed this portion of the verification. You must externally adjust the digitizer to guarantee its accuracy. If the digitizer fails after an external adjustment, return it to NI for repair.
10. Repeat steps 2 through 9 for each iteration in Table 2.
11. Move the shorting cap to channel 1 of the digitizer.
12. Repeat steps 2 through 10 for channel 1. Change **channelList** to `1` when calling the functions `niScope_ConfigureVertical`, `niScope_Read`, and `niScope_FetchMeasurement`.

Table 2. NI 5102 Vertical Offset Specifications

Name	Range	Stimulus Parameters	Success Condition
Vertical Offset	10 V	Short-Circuit Input	$\|x\| < 0.0682$ V
Vertical Offset	2 V	Short-Circuit Input	$\|x\| < 0.0149$ V
Vertical Offset	0.5 V	Short-Circuit Input	$\|x\| < 0.00493$ V
Vertical Offset	0.1 V	Short-Circuit Input	$\|x\| < 0.00227$ V

Verifying Vertical Gain

Complete the following steps to verify NI 5102 vertical gain specifications:

1. Connect the signal generator to channel 0 of the digitizer.
2. Configure the signal generator for a 1 MΩ load.
3. Call `niScope_ConfigureAcquisition` with **acquisitionType** set to `NISCOPE_VAL_NORMAL`.
4. Call `niScope_ConfigureHorizontalTiming` with the following parameters:

- **minSampleRate**: `20,000,000`
- **minNumPts**: `30,000`
- **refPosition**: `50.0`
- **numRecords**: `1`
- **enforceRealTime**: `VI_TRUE`

5. Call `niScope_ConfigureVertical` with the following parameters:
   - **channelList**: `0`
   - **range**: The range listed in Table 3 corresponding to the current iteration
   - **offset**: `0.0`
   - **coupling**: `NISCOPE_VAL_DC`
   - **probeAttenuation**: `1.0`
   - **enabled**: `VI_TRUE`
6. Apply the positive DC voltage listed in the *Stimulus Parameters* column in Table 3 for the current iteration.
7. Call `niScope_Read` to ensure that the hardware is programmed. Set the following parameters:
   - **channelList**: `0`
   - **timeout**: `30`
   - **numSamples**: `128`
8. Wait 2.5 seconds for the scope calibrator output to settle.
9. Call `niScope_InitiateAcquisition`.
10. Call `niScope_FetchMeasurement` with the following parameters:
    - **channelList**: `0`
    - **scalarMeasFunction**: `NISCOPE_VAL_VOLTAGE_AVERAGE`
    - **timeout**: `30`
11. Apply the negative DC voltage listed in the *Stimulus Parameters* column in Table 3 for the current iteration.
12. Wait 2.5 seconds for the scope calibrator output to settle.
13. Call `niScope_InitiateAcquisition`.
14. Call `niScope_FetchMeasurement` with the following parameters:
    - **channelList**: `0`
    - **scalarMeasFunction**: `NISCOPE_VAL_VOLTAGE_AVERAGE`
    - **timeout**: `30`

15. Calculate the error in the vertical gain using the following formula:

$$error = (a - b) - (c - d)$$

where

a = the Measured Positive Voltage
b = the Measured Negative Voltage
c = the Applied Positive Voltage
d = the Applied Negative Voltage

16. Compare the error to the value in the *Success Condition* column in Table 3 for the current iteration. If the error is less than this value, the NI 5102 has passed this portion of the vertical gain test. Otherwise, externally adjust the digitizer as described in the *Adjusting the NI 5102* section. If the digitizer fails after external adjustment, return it to NI for repair.
17. Repeat steps 3 through 16 for each iteration in Table 3.
18. Move the signal generator connection to channel 1 of the digitizer.
19. Repeat steps 3 through 17 for channel 1. Change **channelList** to `1` when calling the functions `niScope_ConfigureVertical`, `niScope_Read`, and `niScope_FetchMeasurement`.

Table 3. NI 5102 Vertical Gain Specifications

Iteration	Range	Stimulus Parameters	Success Condition
1	10 V	±4.5 VDC	$\|x\| < 0.135$ V
2	10 V	±1.5 VDC	$\|x\| < 0.045$ V
3	2 V	±0.9 VDC	$\|x\| < 0.027$ V
4	2 V	±0.5 VDC	$\|x\| < 0.015$ V
5	0.5 V	±0.22 VDC	$\|x\| < 0.0066$ V
6	0.5 V	±0.1 VDC	$\|x\| < 0.003$ V
7	0.1 V	±0.045 VDC	$\|x\| < 0.00135$ V
8	0.1 V	±0.007 VDC	$\|x\| < 0.00021$ V

Verifying Large Signal Bandwidth

To verify NI 5102 large signal bandwidth specifications, complete the following steps:

1. Connect the BNC T connector to channel 0 of the digitizer, and connect the signal generator and 50 Ω terminator to the two inputs on the T connector.
2. Configure the signal generator for a 50 Ω load.
3. Set the signal generator to the frequency and amplitude listed in Table 4 for the Reference Bandwidth entry.
4. Call `niScope_ConfigureVertical` with the following parameters:
   - **channelList**: `0`
   - **range**: `2.0`
   - **offset**: `0`
   - **coupling**: `NISCOPE_VAL_DC`
   - **probeAttenuation**: `1.0`
   - **enabled**: `VI_TRUE`
5. Wait 300 ms for the input stage to settle.
6. Call `niScope_ConfigureHorizontalTiming` with the following parameters:
   - **minNumPts**: `30,000`
   - **refPosition**: `50.0`
   - **numRecords**: `1`
   - **enforceRealTime**: `VI_TRUE`
7. Call `niScope_InitiateAcquisition`.
8. Call `niScope_FetchMeasurement` with the following parameters:
   - **channelList**: `0`
   - **scalarMeasFunction**: `NISCOPE_VAL_AC_ESTIMATE`
   - **timeout**: `30`

   Record this value to use as *reference AC estimate* in step 13.
9. Apply the signal listed in the *Stimulus Parameters* column in Table 4 for the second Bandwidth entry.

10. Call `niScope_ConfigureHorizontalTiming` with the following parameters:
    - **minNumPts**: `30,000`
    - **refPosition**: `50.0`
    - **numRecords**: `1`
    - **enforceRealTime**: `VI_TRUE`
11. Call `niScope_InitiateAcquisition`.
12. Call `niScope_FetchMeasurement` with the following parameters:
    - **channelList**: `0`
    - **scalarMeasFunction**: `NISCOPE_VAL_AC_ESTIMATE`
    - **timeout**: `30`

    Record this value to use as *AC estimate* in step 13.
13. Calculate the response in decibels using the following formula:

$$response = (20\log_{10})\left[\frac{AC\ estimate}{reference\ AC\ estimate}\right]$$

14. Compare *response* to the second range listed in the *Success Condition* column in Table 4. If *response* is outside the given range, the NI 5102 has failed this test. Return the digitizer to NI for repair.
15. Repeat steps 9 through 14 for the last Bandwidth entry in Table 4.
16. Move the signal generator connection to channel 1 of the digitizer
17. Repeat steps 2 through 15 for channel 1. Change **channelList** to `1` for the functions `niScope_ConfigureVertical` and `niScope_FetchMeasurement`.

Table 4. NI 5102 Large Signal Bandwidth Specifications

Name	Min Sample Rate	Stimulus Parameters	Success Condition
Reference Bandwidth (Large Signal)	20,000,000 S/s	100 kHz, 1.9 $V_{pk\text{-}pk}$	—
Bandwidth (Large Signal)	1,000,000 S/s	999,500 Hz, 1.9 $V_{pk\text{-}pk}$ (intentionally aliased)	$\|x\| < 3$ dB
Bandwidth (Large Signal)	10,000,000 S/s	9.9 MHz, 1.9 $V_{pk\text{-}pk}$ (intentionally aliased)	$\|x\| < 3$ dB

Verifying Small Signal Bandwidth

To verify the NI 5102 small signal bandwidth specifications, complete the following steps:

1. Connect the BNC T connector to channel 0 of the digitizer, and connect the signal generator and 50 Ω terminator to the two inputs on the T connector.
2. Configure the signal generator for a 50 Ω load.
3. Set the signal generator to the frequency and amplitude listed in the *Stimulus Parameters* column in Table 5 for the Reference Bandwidth entry.
4. Call `niScope_ConfigureVertical` with the following parameters:
   - **channelList**: `0`
   - **range**: `2 V`
   - **offset**: `0`
   - **coupling**: `NISCOPE_VAL_DC`
   - **probeAttenuation**: `1.0`
   - **enabled**: `VI_TRUE`
5. Wait 300 ms for the input stage to settle.
6. Call `niScope_ConfigureHorizontalTiming` with the following parameters:
   - **minNumPts**: `30,000`
   - **refPosition**: `50.0`
   - **numRecords**: `1`
   - **enforceRealTime**: `VI_TRUE`
7. Call `niScope_InitiateAcquisition`.
8. Call `niScope_FetchMeasurement` with the following parameters:
   - **channelList**: `0`
   - **scalarMeasFunction**: `NISCOPE_VAL_AC_ESTIMATE`
   - **timeout**: `30`

   Record this value to use as *reference AC estimate* in step 13.
9. Apply the signal specified in the *Stimulus Parameters* column in Table 5.

10. Call `niScope_ConfigureHorizontalTiming` with the following parameters:
    - **minNumPts**: `30,000`
    - **refPosition**: `50.0`
    - **numRecords**: `1`
    - **enforceRealTime**: `VI_TRUE`
11. Call `niScope_InitiateAcquisition`.
12. Call `niScope_FetchMeasurement` with the following parameters:
    - **channelList**: `0`
    - **scalarMeasFunction**: `NISCOPE_VAL_AC_ESTIMATE`
    - **timeout**: `30`

    Record this value to use as *AC estimate* in step 13.
13. Calculate the response in decibels using the formula:

$$response = (20\log_{10})\left[\frac{AC\ estimate}{reference\ AC\ estimate}\right]$$

14. Compare *response* to the range listed in the *Success Condition* column in Table 5. If *response* is outside the given range, the NI 5102 has failed this test. Return the digitizer to NI for repair.
15. Repeat steps 9 through 14 for the remaining bandwidth entries in Table 5.
16. Repeat steps 2 through 15 with **coupling** set to `NISCOPE_VAL_AC` for the function `niScope_ConfigureVertical`.
17. Move the signal generator connection to channel 1 of the digitizer.
18. Repeat steps 3 through 16 for channel 1. Change **channelList** to `1` for the functions `niScope_ConfigureVertical` and `niScope_FetchMeasurement`.

Table 5. NI 5102 Small Signal Bandwidth Specifications

Name	Digitizer Parameters	Stimulus Parameters	Success Condition
Reference Bandwidth (Small Signal)	**minSampleRate** = 20,000,000 S/s **bandwidth** = `NISCOPE_VAL_FULL_BANDWIDTH` (`0.0` in LabVIEW)	100 kHz, 0.2 V_{pk-pk}	—
Bandwidth (Small Signal)	**minSampleRate** = 1,000,000 S/s	999,500 Hz, 0.2 V_{pk-pk} (intentionally aliased)	$\|x\| < 3$ dB
Bandwidth (Small Signal)	**minSampleRate** = 5,000,000 S/s	14.9 MHz, 0.2 V_{pk-pk} (intentionally aliased)	$\|x\| < 3$ dB

Verifying Input Impedance

To verify the NI 5102 input impedance specifications, complete the following steps:

1. Connect the signal generator to channel 0 of the digitizer.
2. Call `niScope_ConfigureVertical` with the following parameters:
   - **channelList**: `0`
   - **range**: The range values listed in Table 6
   - **offset**: `0.0`
   - **coupling**: `NISCOPE_VAL_DC`
   - **probeAttenuation**: `1.0`
   - **enabled**: `VI_TRUE`
3. Call `niScope_Read` to ensure that the hardware is programmed. Set the following parameters:
   - **channelList**: `0`
   - **timeout**: `30`
   - **numSamples**: `128`
4. Wait 1 second for the input stage to settle.
5. Measure the impedance (x) on the signal generator and compare it to the *Success Condition* column in Table 6. If x is outside the given range, the NI 5102 has failed this test. Return the digitizer to NI for repair.
6. Repeat steps 2 through 5 for each range listed in Table 6.

7. Move the signal generator connection to channel 1 of the digitizer.
8. Repeat steps 2 through 6 for channel 1. Change **channelList** to `1` when calling the functions `niScope_configureVertical` and `niScope_Read`.

Table 6. NI 5102 Input Impedance Specifications

Range	Success Condition
0, 2, 0.5, and 0.1	990,000 < *x* < 1,010,000 Ω

Verifying AC Coupling Cutoff Frequency

To verify the NI 5102 AC coupling cutoff frequency specifications, complete the following steps:

1. Connect the signal generator to channel 0 of the digitizer.
2. Configure the signal generator for a 1 MΩ load, and set the frequency and amplitude as listed in Table 7.
3. Call `niScope_ConfigureVertical` with the following parameters:
   - **channelList**: `0`
   - **range**: `2.0`
   - **offset**: `0.0`
   - **coupling**: `NISCOPE_VAL_DC`
   - **probeAttenuation**: `1.0`
   - **enabled**: `VI_TRUE`
4. Call `niScope_ConfigureHorizontalTiming` with the following parameters:
   - **minSampleRate**: `10,000`
   - **minNumPts**: `30,000`
   - **refPosition**: `50.0`
   - **numRecords**: `1`
   - **enforceRealTime**: `VI_TRUE`
5. Call `niScope_Read` to ensure that the hardware is programmed. Set the following parameters:
   - **channelList**: `0`
   - **timeout**: `30`
   - **numSamples**: `128`
6. Wait 1 second for the input stage to settle.
7. Call `niScope_InitiateAcquisition`.

8. Call `niScope_FetchMeasurement` with the following parameters:
   - **channelList**: `0`
   - **scalarMeasFunction**: `NISCOPE_VAL_AC_ESTIMATE`
   - **timeout**: `30`

   Record this value to use as *AC estimate with DC coupling* in step 14.
9. Call `niScope_ConfigureVertical` with the following parameters:
   - **channelList**: `0`
   - **range**: `2.0`
   - **offset**: `0.0`
   - **coupling**: `NISCOPE_VAL_AC`
   - **probeAttenuation**: `1.0`
   - **enabled**: `VI_TRUE`
10. Call `niScope_Read` to ensure that the hardware is programmed. Set the following parameters:
    - **channelList**: `0`
    - **timeout**: `30`
    - **numSamples**: `128`
11. Wait 500 ms for the input stage to settle.
12. Call `niScope_InitiateAcquisition`.
13. Call `niScope_FetchMeasurement` with the following parameters:
    - **channelList**: `0`
    - **scalarMeasFunction**: `NISCOPE_VAL_AC_ESTIMATE`
    - timeout: `30`

    Record this value to use as *AC estimate with AC coupling* in step 14.
14. Calculate the response in decibels using the following formula:

$$response = 20\log_{10}\left[\frac{AC\ estimate\ with\ AC\ coupling}{AC\ estimate\ with\ DC\ coupling}\right]$$

15. Compare *response* to the value in the *Success Condition* column in Table 7. If *response* is outside the listed range, the NI 5102 has failed this test. Return the digitizer to NI for repair.
16. Repeat steps 3 through 15 for the last entry in Table 7.
17. Move the signal generator connection to channel 1 of the digitizer.
18. Repeat steps 3 through 16 for channel 1. Change **channelList** to `1` when calling the functions `niScope_ConfigureVertical`, `niScope_Read`, and `niScope_FetchMeasurement`.

Table 7. NI 5102 AC Coupling Cutoff Specifications

Name	Stimulus Parameters	Success Condition
AC Coupling	12.1 Hz, 1.8 V_{pk-pk}	|x| < 3 dB
AC Coupling	9.9 Hz, 1.8 V_{pk-pk}	|x| > 3 dB

Verifying Timing

Complete the following steps to verify the NI 5102 timing specifications:

1. Connect the signal generator to channel 0 of the digitizer.
2. Configure the signal generator for a 1 MΩ load.
3. Set the signal generator to output a 10 kHz, 1.8 V_{pk-pk} sine wave.
4. Call `niScope_ConfigureVertical` with the following parameters:
   - **channelList**: `0`
   - **range**: `2.0`
   - **offset**: `0.0`
   - **coupling**: `NISCOPE_VAL_DC`
   - **probeAttenuation**: `1.0`
   - **enabled**: `VI_TRUE`
5. Call `niScope_ConfigureHorizontalTiming` with the following parameters:
   - **minSampleRate**: `1,000,000`
   - **minNumPts**: `100,000`
   - **refPosition**: `50.0`
   - **numRecords**: `1`
   - **enforceRealTime**: `VI_TRUE`
6. Call `niScope_Read` to ensure that the hardware is programmed. Set the following parameters:
   - **channelList**: `0`
   - **timeout**: `30`
   - **numSamples**: `128`
7. Wait 50 ms for the input stage to settle.
8. Call `niScope_InitiateAcquisition`.

9. Call `niScope_FetchMeasurement` with the following parameters:
   - **channelList**: `0`
   - **scalarMeasFunction**: `NISCOPE_VAL_AVERAGE_FREQUENCY`
   - **timeout**: `30`
10. If the returned frequency value does not fall between 9,999 and 10,001 Hz, a hardware error exists. If the value falls outside the specified range, terminate the verification procedure and return the digitizer to NI for repair.
11. Set the signal generator to output a 1.8 $V_{pk\text{-}pk}$, 10 MHz sine wave. This wave is intentionally undersampled. The sampling rate is an even multiple of the sine wave frequency.
12. Call `niScope_InitiateAcquisition`.
13. Call `niScope_FetchMeasurement` with the following parameters:
    - **channelList**: `0`
    - **scalarMeasFunction**: `NISCOPE_VAL_AVERAGE_PERIOD`
    - **timeout**: `30`

    Record the *period* measurement to use in step 15.
14. If the returned status is `NISCOPE_ERROR_UNABLE_TO_PERFORM_MEASUREMENT`, call `niScope_errorHandler` with **errorCode** set to the returned error value. If the timing is perfectly aliased, the waveform is a DC level and the period measurement fails. If the error description indicates the measurement failed due to insufficient crosspoints, the device passed this portion of the test.
15. If the return status is anything other than `NISCOPE_ERROR_UNABLE_TO_PERFORM_MEASUREMENT`, calculate the actual sample rate (x), assuming a perfect source, with the following formula:

$$x = \frac{\textit{specified sample rate} \times \textit{source frequency} \times \textit{period}}{\textit{source frequency} \times \textit{period} - 1}$$

    which is:

$$x = \frac{10^{13} \times \textit{period}}{10^{7} \times \textit{period} - 1}$$

16. Compare the actual sample rate (x) to the success condition, $999{,}950 < x < 1{,}000{,}050$ Hz. If the sample rate is outside this range, return the digitizer to NI for repair.
17. Move the signal generator connection to channel 1 of the digitizer.

18. Repeat steps 3 through 16 for channel 1. Change **channelList** to `1` when calling `niScope_ConfigureVertical`, `niScope_Read`, and `niScope_FetchMeasurement`.

Verifying Trigger Sensitivity

To verify trigger sensitivity, you must determine the smallest signal on which the digitizer can trigger by trying all possible trigger levels. Complete the following steps:

1. Connect the signal generator to the trigger channel input of the digitizer.
2. Configure the signal generator for a 1 MΩ load.
3. Apply a 1 MHz sine wave with zero vertical offset and peak-to-peak voltage as listed in Table 8.
4. Call `niScope_ConfigureVertical` with the following parameters:
   - **channelList**: `0`
   - **range**: `10.0`
   - **offset**: `0.0`
   - **coupling**: `NISCOPE_VAL_DC`
   - **probeAttenuation**: `1.0`
   - **enabled**: `VI_TRUE`
5. Wait 10 ms for the input stage to settle.
6. Call `niScope_ConfigureHorizontalTiming` with the following parameters:
   - **minSampleRate**: `20,000,000`
   - **numSamples**: `128`
   - **refPosition**: `50.0`
   - **numRecords**: `1`
   - **enforceRealTime**: `VI_TRUE`
7. Call `niScope_ConfigureTriggerEdge` with the following parameters:
   - **triggerSource**: `NISCOPE_VAL_EXTERNAL`
   - **holdoff**: `0`
   - **delay**: `0`
   - **level**: The trigger level as discussed in step 10
   - **slope**: `NISCOPE_VAL_POSITIVE`
   - **triggerCoupling**: `NI_SCOPE_VAL_AC`

8. Call `niScope_Read` to read a waveform. Set the following parameters:
   - **channelList**: `0`
   - **timeout:** `0.1`
   - **numSamples**: `128`
9. Call `niScope_Abort` to stop the test.
10. If the digitizer did not time out, the channel has passed the test. If the digitizer timed out, increment the level setting by the **trigger level delta** specified in Table 8, then repeat steps 7 through 9 until the level setting exceeds the **high trigger level** entry in Table 8. If incrementing the trigger level by the **trigger level delta** results in a trigger level greater than the **high trigger level** in Table 8, this channel fails the test.
11. Connect the signal generator to channel 0 of the digitizer.
12. Repeat steps 2 through 10 to test the trigger sensitivity on channel 0. Make the following changes:
    - Change **channelList** to `0` when calling `niScope_Read` and `niScope_ConfigureVertical`
    - Change **triggerSource** to `0` when calling `niScope_ConfigureTriggerEdge`
13. Repeat steps 1 through 12 to test the trigger sensitivity on channel 1. Make the following changes:
    - Change **channelList** to `1` when calling `niScope_Read` and `niScope_ConfigureVertical`
    - Change **triggerSource** to `1` when calling `niScope_ConfigureTriggerEdge`

The digitizer passes the trigger sensitivity test only if all channels pass the test. If any channel fails the test, return the digitizer to NI for repair.

Table 8. NI 5102 Trigger Sensitivity Specifications

Name	Digitizer Parameters	Stimulus Parameters	Success Condition
Trigger Sensitivity	**low trigger level** = –0.5 **high trigger level** = 0.5 **trigger level delta** = 0.01	500 mV_{pk-pk}	digitizer triggers with any valid trigger level

Adjusting the NI 5102

If the verification procedure determines that the digitizer is out of specification, you need to adjust the calibration constants.

The NI 5102 has no internal reference voltage, so external connections are required for vertical range and offset adjustments. The external adjustment is completely independent for each channel and vertical range setting combination. You can perform the verification and adjustment for all the ranges or for only the vertical ranges in question. The adjustment procedure adjusts the calibration constants stored in the external calibration area of the EEPROM and is equivalent to a factory calibration. The procedure is password-protected so that users cannot accidentally modify calibration constants. You can change the password using the function `niScope_CalChangePassword`.

To adjust the calibration constants of the NI 5102, complete the following steps:

1. Call `niScope_CalStart` to obtain a calibration-specific session handle. You must provide the external calibration password, which defaults to `0` or the empty string, `""`. Set the following parameters:
   - **resourceName**: A string assigned by Measurement & Automation Explorer (MAX), such as `DAQ::1`
   - **password**: Default password is `0` or `""`
   - **newSessionHandle**: The returned session handle
2. Short-circuit the selected channel of the digitizer and call `niScope_CalAdjustOffset` to perform a preliminary offset calibration for the selected range and channel. Set the following parameters:
   - **sessionHandle**: The value returned by `niScope_CalStart`
   - **channelName**: The string name of the channel, such as `0` or `1`
   - **range**: The voltage range you want to adjust
3. Connect the signal generator to channel 0.
4. Configure the signal generator for a 1 MΩ load.
5. Apply the positive stimulus as specified in the *Stimulus Parameters* column in Table 9.
6. Call `niScope_CalAdjustRange` to adjust the vertical range of the specified channel. Set the following parameters:
   - **sessionHandle**: The value returned by `niScope_CalStart`
   - **channelName**: The string name of the channel, such as `0` or `1`

- **range**: The voltage range you want to adjust
- **stimulus**: The positive DC voltage you apply; refer to Table 9 for the proper stimulus for each vertical range entry

7. Apply a negative stimulus as specified in the *Stimulus Parameters* column in Table 9.
8. Call `niScope_CalAdjustRange` to adjust the vertical range of a specified channel. Set the following parameters:
   - **sessionHandle**: The value returned by `niScope_CalStart`
   - **channelName**: The string name of the channel, such as `0` or `1`
   - **range**: The voltage range you want to adjust
   - **stimulus**: The negative DC voltage you apply; refer to Table 9 for the proper stimulus for each vertical range entry
9. Short-circuit the input channel and call `niScope_CalAdjustOffset` to perform an offset calibration using the calibrated vertical range from the previous step. Set the following parameters:
   - **sessionHandle**: The value returned by `niScope_CalStart`
   - **channelName**: The string name of the channel, such as `0` or `1`
   - **range**: The voltage range you want to adjust; refer to Table 9 to obtain the value for each vertical range
10. Repeat steps 2 through 9 for each channel and vertical range you want to adjust.
11. Call `niScope_CalSelfCalibrate` to self-calibrate the digitizer. Set the following parameters:
    - **sessionHandle**: The session handle returned by `niScope_CalStart` or `niScope_init`
    - **channelName**: Ignore this parameter; use `VI_NULL`
    - **option**: Use `VI_NULL` for a normal self-calibration operation; only `NISCOPE_VAL_CAL_RESTORE_EXTERNAL_CALIBRATION` is supported
12. Call `niScope_CalEnd` to release the session handle. Set the following parameters:
    - **sessionHandle**: The session handle returned by `niScope_CalStart`
    - **action**: `NISCOPE_VAL_CAL_ACTION_STORE` to store the calibration constants in the EEPROM; this option stores the external calibration date and the incremented external calibration count in the EEPROM

The vertical range and offset constants of the digitizer are now adjusted with respect to the external source.

Table 9. NI 5102 Calibration Stimuli

Calibration Step	Range	Stimulus Parameters
Vertical Range	10.0 V	±4.25 VDC
Vertical Range	2.0 V	±0.85 VDC
Vertical Range	0.5 V	±0.21 VDC
Vertical Range	0.1 V	±0.04 VDC

Verifying the New Calibration Constants

NI recommends that you reverify the NI 5102 operating specifications after adjustment by repeating the verification procedures in the *Verifying the Performance of the NI 5102* section. If the digitizer fails any test immediately after you perform an external calibration, return it to NI for repair.

Where to Go for Support

The National Instruments Web site is your complete resource for technical support. At ni.com/support you have access to everything from troubleshooting and application development self-help resources to email and phone assistance from NI Application Engineers.

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